Satellite Position Determination of LEO Spacecraft

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Things to follow...

- **Brief background on LEO and SPS**

- **Various application of a space bound receiver**

- **Software development for IRS – Ground and on-board**

- **Results**

- **conclusion**

LEO Orbit Determination methods

- Conventional
  - Two way ranging from various ground stations
  - Required data duration: 2.5 days
  - Achievable Accuracy : 150 –200 meters
- GPS Based single frequency code
  - One way ranging data
  - Required data duration: 200 minutes
  - Achievable Acuuracy: 10-15 meters

Satellite Positioning System (SPS)

- 8 channel single frequency C/A code GPS Rx

- Instantaneous position and velocity at every second

- Pseudo Ranges & Delta Pseudo Ranges

- Position accuracy 70 meters (3sigma)

- Velocity accuracy 2.0 met/sec (3sigma)

- Limitation: Solutions (Position and Velocity) are noisy, can not use for future prediction directly

SPS Data Streams in LEO

- **House Keeping Telemetry (HK - TLM (16/32 sec))**
  - **IRS state vector + Health**
- **SPS- Real Time (RT(1 sec))**
  - **IRS state vector + Raw Measurements**
  - **Typically 10-15 minutes duration**
- **Data Handling (DH-RT (1 sec))**
  - **IRS state vector + Raw Measurements**
  - **Typically 10-15 minutes duration**
  - **Through Attitude and Orbit Control System (AOCS) interface**
- **SPS- Play Back (PB (10 sec))**
  - **IRS state vector + Raw Measurements**
  - **Typically 2 orbits duration**

LEO SATELLITES with SPS

REMOTE SENSING

Orbital Characteristics

<u>Altitude</u>:   600 – 700 kms
<u>Inclination</u> :   ~ 97⁰
<u>Orbit Type</u>:   sun synchronous

<u>Imaging</u>: Nadir Pointing
                    Step and Stare

<u>Resolution:</u> 1 – 5 meters

<u>Satellites</u> : TES (2001)
                IRS-P6(2003)
                CARTO-1(2005)
                CARTO-2(2007)
                CARTO-2A(2008)
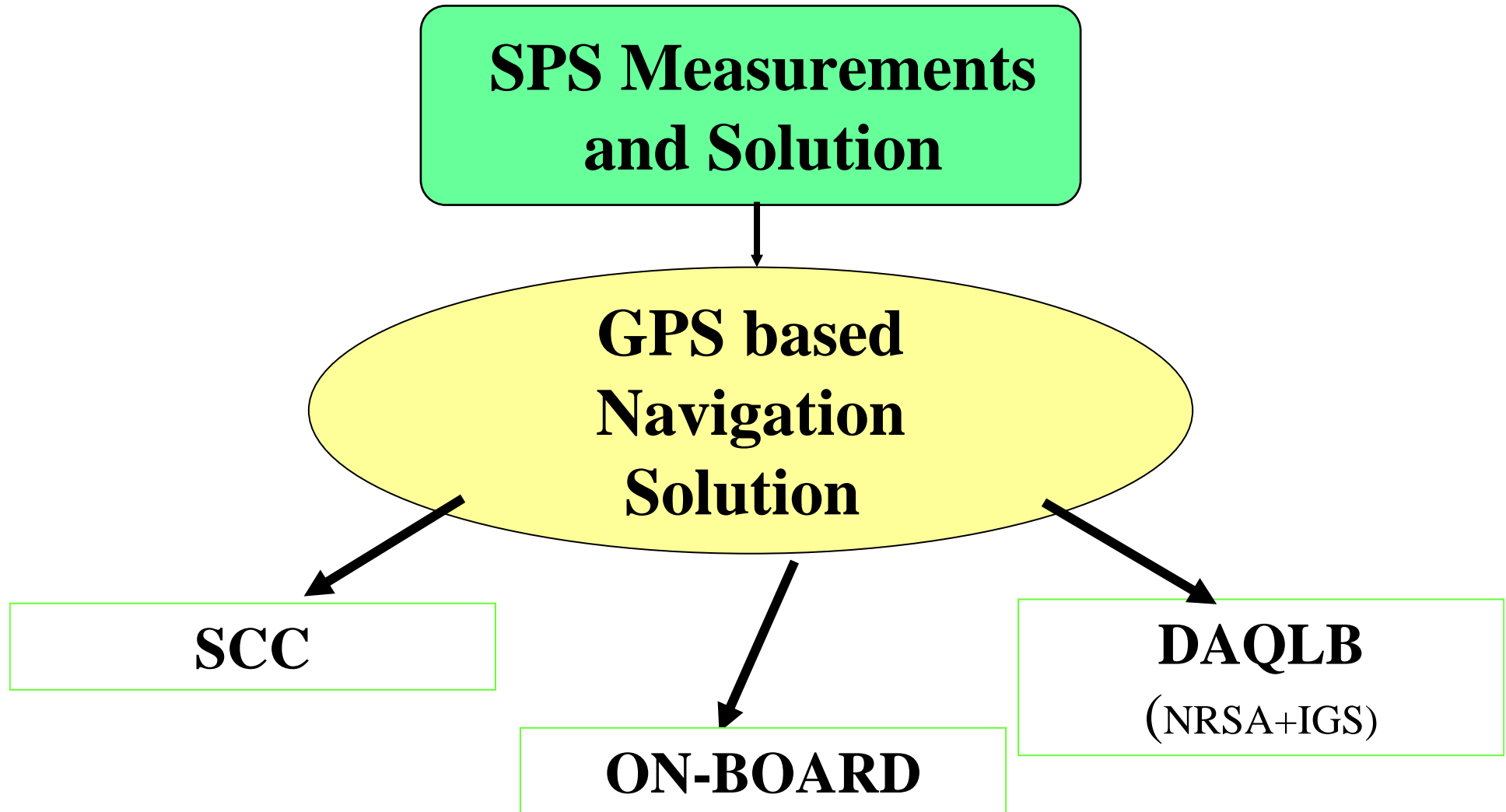   TWSAT (2008)

OCEAN COLOUR MONITORING

- OCEANSAT-1 (1999)
- OCEANSAT-2 (2008)

ATMOSPHERIC SCIENCE SATELLITES

- OCEANSAT-2 (2008)
- Megha-Tropiques (2009)

ASTRONOMY SATELLITES

- ASTROSAT (2009)

Major Applications of SPS in LEO

SPS Measurements and Solution

GPS based Navigation Solution

SCC

ON-BOARD

DAQLB
(NRSA+IGS)

SCC – Spacecraft Control Centre
DAQLB – Data Products

Orbit Requirement for the Mission (Ground)

- **<u>Initial Phase</u>:**
  - Performance Evaluation at SCC of Onboard SPS
  - Preliminary Orbit Information at SCC after Injection
  - Performance Evaluation of <u>G</u>PS Based <u>O</u>nboard <u>O</u>rbit <u>D</u>etermination <u>S</u>/w (GOODS) at SCC

- **<u>Normal Phase</u>:**
  - Orbit determination S/w at SCC using SPS-PB data for Ground Station visibility and payload planning
  - State vector for payload data products generation (DAQLB)
  - Long term SPS performance evaluation

THE ABOVE REQUIREMENTS ARE REALIZED USING:

SANGAM: <u>SA</u>tellite <u>N</u>avigation using <u>G</u>PS <u>A</u>ided <u>M</u>easurements
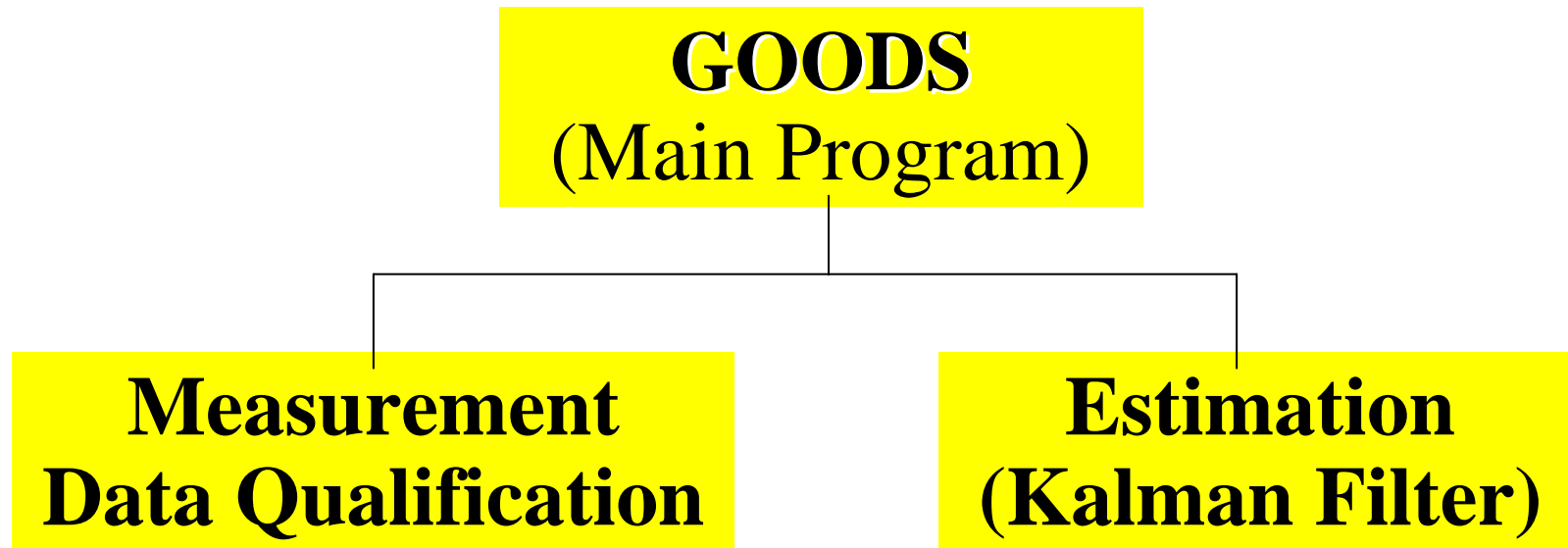
SANGAM s/w
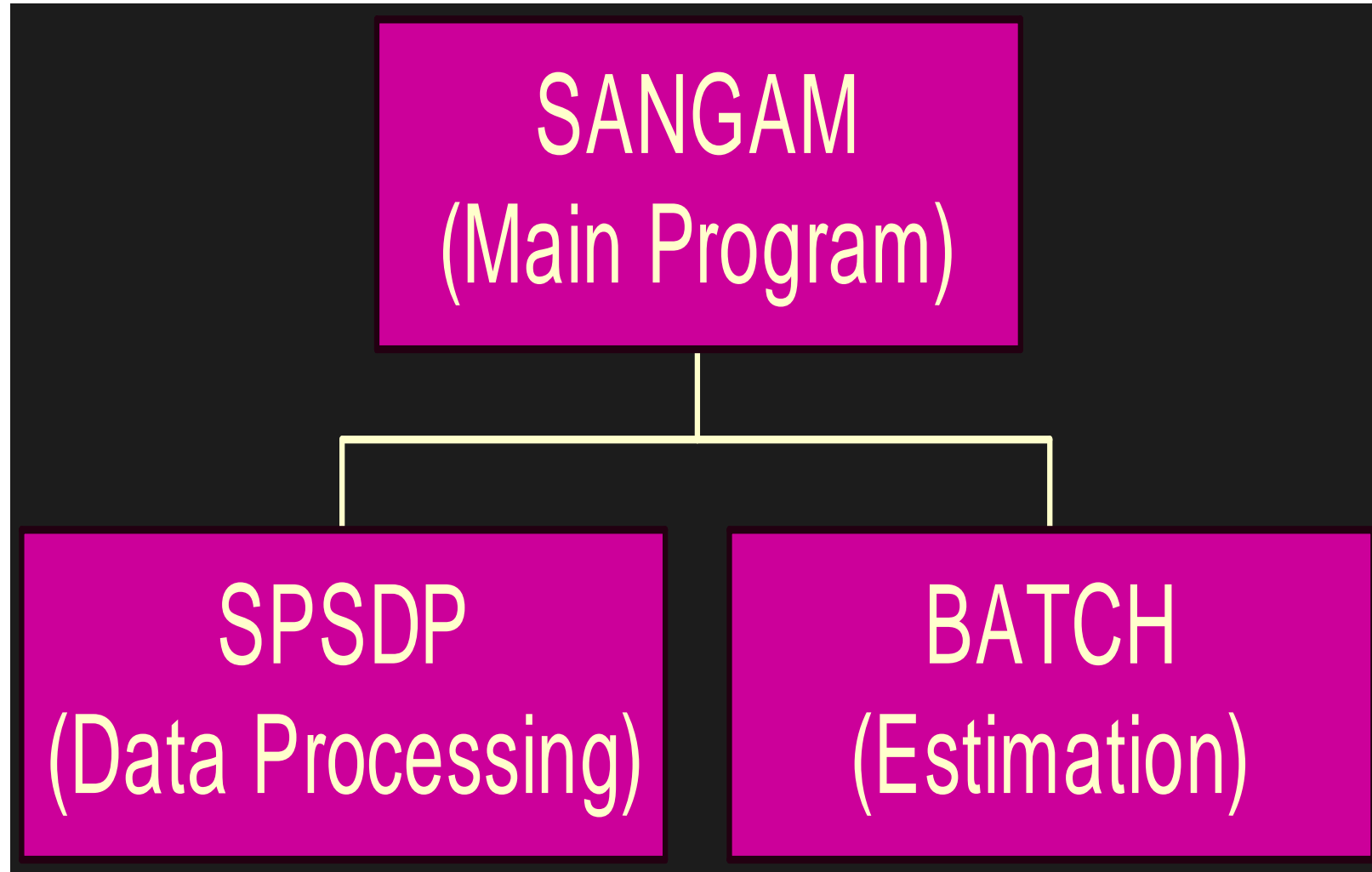
Orbit Requirement for the Mission (On-Board)

- **Accurate position of satellite every 512 millisecond for Attitude Determination using Star Sensor**

- **State Vector prediction at future time for:**

    - **on-board image planning**

    - **Station visibility for downloading payload data**

- **Orbit propagation during non-availability of SPS data**
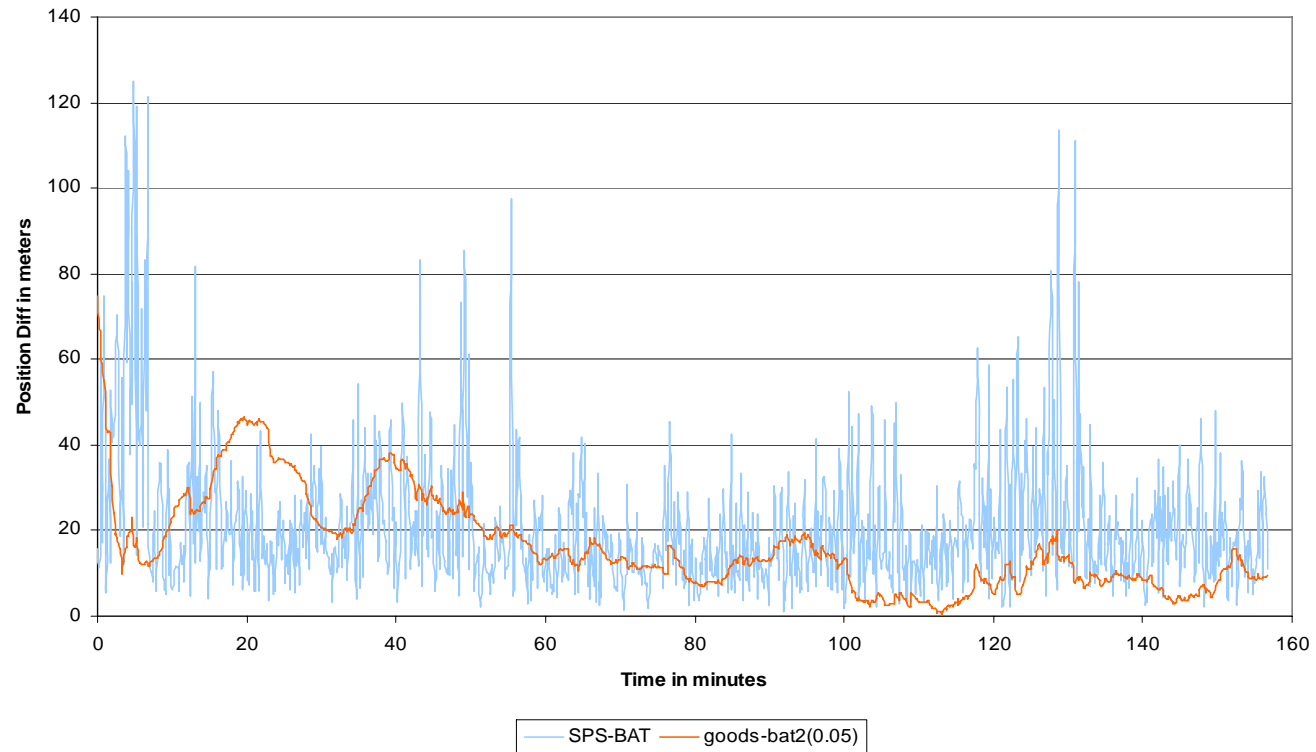
THE ABOVE REQUIREMENTS ARE RELIZED USING:
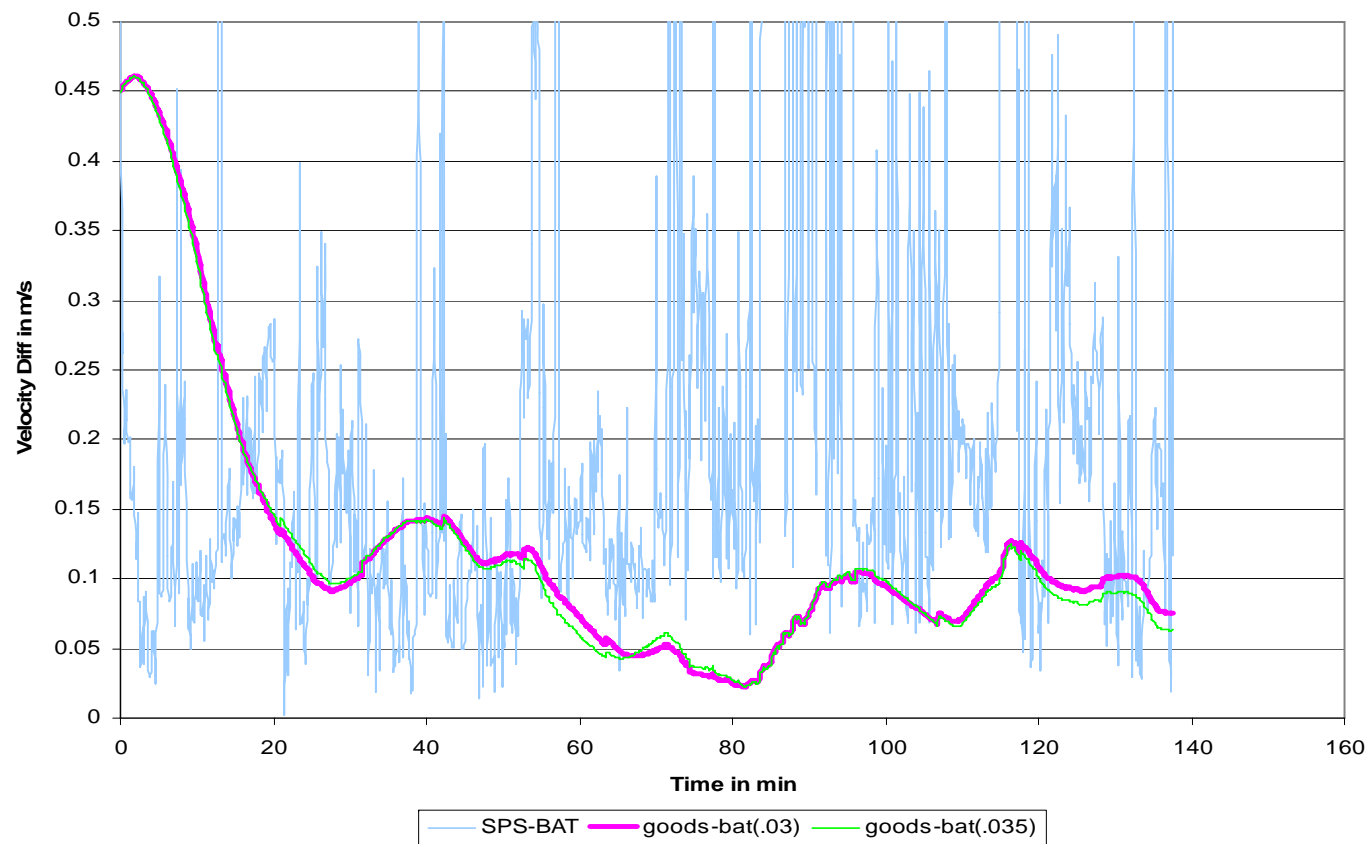
GOODS: GPS based On-board Orbit Determination Software

GOODS

```
┌─────────────────────────┐
│          GOODS          │
│      (Main Program)     │
└─────────────────────────┘
           │
     ┌─────┴─────┐
     │           │
┌──────────────┐ ┌──────────────┐
│ Measurement  │ │  Estimation  │
│Data          │ │(Kalman       │
│Qualification │ │ Filter)      │
└──────────────┘ └──────────────┘
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Position differences

Goods constant gain orbit 2387(p5); ref-SANGAMPB;

Velocity Differencess

Goods constant gain orbit 2372(P5);

CONCLUSION

- Single frequency code receiver measurement
  - LEO satellite orbit determined to the accuracy of 10-15 meters realised through SANGAM S/W
  - Onboard requirements are realized through GOODS s/w
- Dual frequency carrier receiver measurement
  - Precise orbit determination of OCEANSAT-2 to the accuracy of less than a meter will be realised
  - Atmospheric parameter will be retrieved from GPS radio occultation technique

THANK YOU

SENSOR REQUIREMENTS

- Multi-frequency dual polarsisation high sensitivity, large swath / scanning-type

  MADRAS: Microwave Analysis and Detection of Rain and Atmospheric structures

- Millimetrewave Humidity Sounder

  SAPHIR: Scanner for Atmospheric Profiling of Humidity in the Inter-Tropics

- **ScaRaB**: Four-channel Scanner for Radiation Budget
- **GPS - ROS**: GPS Radio-Occultation System

MEGHA-TROPIQUES MISSION OBJECTIVES

1. To collect a long-term set of measurements with a good sampling and coverage over Tropical latitudes to understand better the processes related to tropical convective systems and their life cycle.

2. To improve the determination of atmospheric energy and water budget in the tropical area at various time and space scales.

3. To study tropical climatic events and their predictability : droughts, monsoon variability, floods, tropical cyclones ...